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## NOTICES FROM THE LICK OBSERVATORY.\*

PREPARED BY MEMBERS OF THE STAFF.

### ON THE VARIABLE VELOCITY OF *POLARIS* IN THE LINE OF SIGHT.

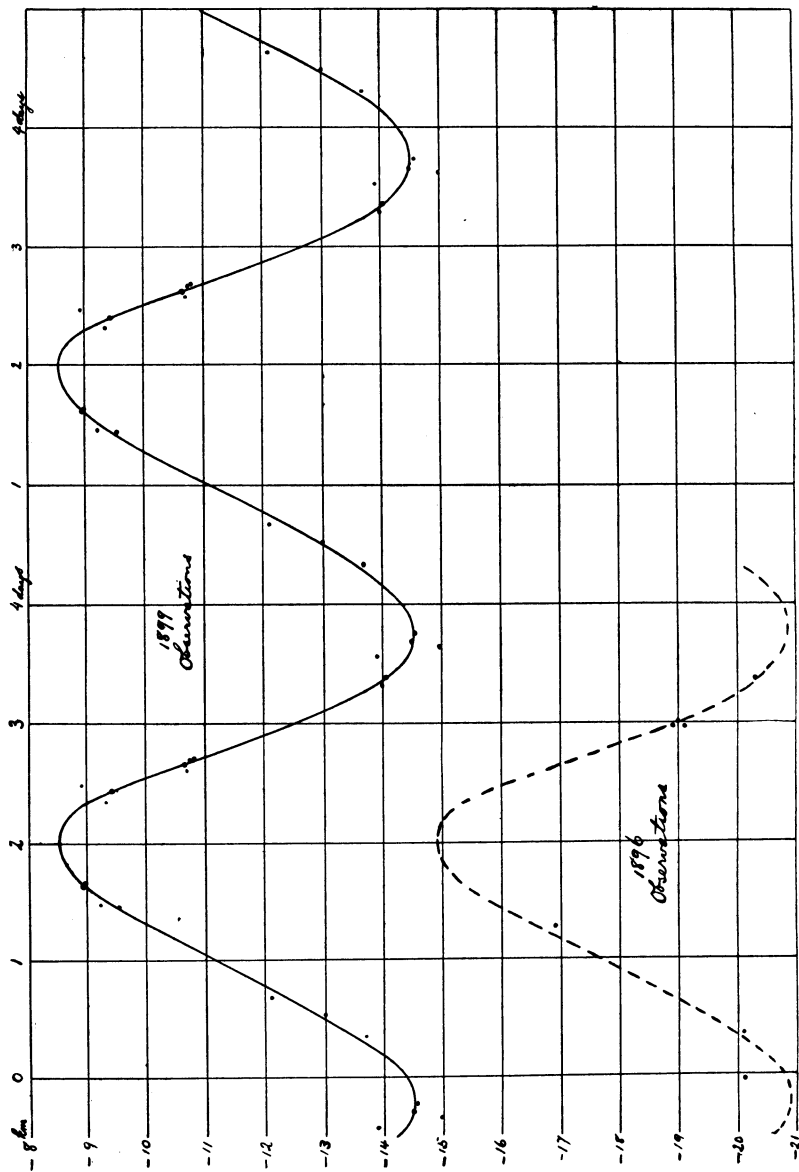
Six measures of the velocity of *Polaris* in the line of sight were secured at the Lick Observatory in 1896, as follows:—

1896, Sept. 8,	— 20.1 <sup>km</sup> per second.
“ 15,	— 19.1
“ 23,	— 18.9
Oct. 5,	— 19.0
Nov. 11,	— 20.1
Dec. 8,	— 20.3

The negative sign is used to indicate approach toward the Solar System. These results, extending over a period of three months, are in such excellent agreement that the velocity of this star was not suspected to be variable. The extreme range of 1.4<sup>km</sup> is no larger than would be expected from the unavoidable errors of observation. The velocity of the star was assumed to be — 19.6<sup>km</sup>, the mean of the six separate results.

Following my custom of securing frequent checks on the current results of observation, by remeasuring the velocity of *Venus*, *Mars*, or some of the brighter stars, an additional spectrogram of *Polaris* was obtained on 1899, August 8th. Measurement of the plate gave a velocity of — 13.0<sup>km</sup>, or an apparent change since 1896 of 6.6<sup>km</sup>. In order to test the matter further, on August 9th, spectrograms of *Polaris* and of  $\beta$  and  $\gamma$  *Andromedæ* were secured. That of *Polaris* gave a result of — 10.6<sup>km</sup>, whereas those of  $\beta$  and  $\gamma$  *Andromedæ* reproduced the values obtained for these stars in previous years. Additional plates of *Polaris*, on August 14th and 15th, gave results of — 8.9 and — 14.9<sup>km</sup>, leaving no doubt that the star was a binary of comparatively short period,

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VELOCITY-CURVE FOR OBSERVATIONS OF POLARIS IN THE LINE OF SIGHT,

and the investigations were continued. Following are the velocities observed in 1899, up to date:—

Greenwich mean time.	Velocity.	Measures by
1899, Aug. 9 <sup>d</sup> 0 <sup>h</sup> 46 <sup>m</sup>	— 13.0 <sup>km</sup>	CAMPBELL.
9 20 5	— 11.2	“
9 20 5*	— 11.1	“
9 20 5†	— 10.1	WRIGHT.
14 22 45	— 8.9	CAMPBELL.
16 0 8	— 13.9	“
23 0 19	— 10.7	“
24 0 49	— 15.1	“
24 0 49†	— 14.8	WRIGHT.
26 0 55	— 9.4	CAMPBELL.
26 0 55†	— 8.5	WRIGHT.
27 0 18	— 10.6	CAMPBELL.
27 16 12	— 14.0	“
28 0 47	— 14.7	“
28 0 47†	— 14.3	WRIGHT.
28 16 19	— 13.7	“
29 0 25	— 12.1	“
29 18 49	— 9.6	“
29 23 57	— 8.9	“
30 16 10	— 9.3	“
Sept. 4 16 11	— 14.1	“
6 18 6	— 9.2	CAMPBELL.
11 16 13	— 9.4	“
11 22 29	— 10.7	WRIGHT.
11 23 5	— 11.0	CAMPBELL.
12 23 33	— 14.6	“

By plotting these velocities with reference to the times of observation, it was found that the velocity varied from about  $8\frac{1}{2}^{\text{km}}$  to  $14\frac{1}{2}$ , and back to  $8\frac{1}{2}$  in a little less than four days. Assuming a period of  $3^{\text{d}} 23^{\text{h}} 15^{\text{m}}$ , which may be slightly in error, the observations are charted as black dots in the upper portion of the accompanying illustration, in the space lying between 0 and 4 days. They are repeated, in order to reproduce the cycle, in the space between 4 days and 4 days. The smooth curve, drawn as well as possible through the charted points, is the velocity-curve

\* A remeasurement of the same plate, which is the poorest one in the 1899 series.

† Measures of the same plates by Mr. WRIGHT.

of the bright *Polaris* in its revolution around the center of gravity of itself and an invisible companion. Some slight doubt exists as to the form of the curve in the regions below 1, 2, 3, 4, etc., since these portions correspond to our daytime, when observations could not be secured. In the course of a few revolutions these portions will correspond to night-time, and observations to locate them will be obtained.

A preliminary computation shows that the orbit of *Polaris* around the center of gravity is nearly circular, the eccentricity of its ellipse being about 0.15. The major semi-axis of the ellipse, multiplied by the cosine of the angle which the plane of the orbit makes with the line of sight, is about 160,000<sup>km</sup>; or less than half the distance between the Earth and Moon. While we may never know the angle of inclination, we are justified in saying that the orbit of *Polaris* around the center of gravity is probably comparable in size with the orbit of the Moon around the Earth. Just as the center of gravity of the Earth and Moon lies within the Earth's surface, so is it probable that the center of gravity of *Polaris* and its close companion falls inside of the bright *Polaris*. The velocity of this center of gravity with reference to the Solar System is at present about  $-11.7^{\text{km}}$  per second.

The point of greatest interest brought out by the observations is that the results obtained in 1896 lie far outside the present range of velocities. A little of the discrepancy might be due to a revolution of the line of apsides of the elliptical orbit, described above; but I think the greater part of it must be due to a change in the velocity of the center of gravity of the binary system, produced by the attraction of a third body.

It happened that the six plates of 1896, referred to above, were secured at intervals differing less than half a day from multiples of the period of the binary system. They would, therefore, show but little change in velocity. Very recently, while taking the observational data for the plate of 1896, November 11th, out of my note-book, I chanced to see, on a neighboring page, the record of another plate of *Polaris* obtained on 1899, November 12th, accompanied by the note that it was a defective plate, given to a San Francisco astronomer. The plate was at once written for, and received. It is a very poor plate, but measurable. It gave a velocity of  $-16.9^{\text{km}}$ .

Charting the 1896 observations with reference to the assumed period,  $3^{\text{d}} 23^{\text{h}} 15^{\text{m}}$ , they fall as shown in the lower portion of the

illustration. They are well represented by the dotted curve, which is of the same form as the curve for 1899, immediately above it.

If the forms of the velocity-curves of the binary system are the same for 1896 and 1899, the present velocity of the center of gravity of the binary system differs about  $6\frac{1}{2}$  km from its value in 1896.

The observations were made with the Mills spectrograph attached to the 36-inch telescope.

W. W. CAMPBELL.

1899, September 30.

#### PHOTOGRAPHIC EFFICIENCY OF THE CROSSLEY REFLECTOR.

The reflecting telescope has been so little used in this country, since the time of HENRY DRAPER, that a few notes on the photographic efficiency of the Crossley reflector may be of interest to American readers.

The Crossley dome is built on the farther end of a long rocky spur, which extends from the principal summit of Mt. Hamilton toward the south, and is within a few minutes' walk (or climb) of the main Observatory. The mirror, which has a very fine figure, has an aperture of three feet, and a focal length of seventeen feet six inches. The mounting, as compared with the beautifully mounted large refractors of the Observatory, is undoubtedly a rude piece of mechanism, but with sufficient experience of its numerous idiosyncrasies, the observer can obtain negatives with exposures of four hours' duration, with only an occasional failure.

At present the Crossley telescope is being used for photographic observations of nebulae. For such work the summer months at Mt. Hamilton present almost ideal conditions. The sky is continuously and often brilliantly clear, while the dryness and purity of the air are such that the silvered surfaces retain their brilliancy without any care on the part of the observer. Within the last week, however, the smoke from forest fires (from which there seems to be no escape in even the remotest corners of the earth) has greatly dulled the brightness of the sky, and has interfered most annoyingly with the photographic work. In the winter months, on the other hand, the conditions are generally bad, on account of storms, snow, fog, or dampness; yet there are many nights, between the spells of bad weather, on which the telescope can be used.